U.S. DEPARTMENT OF COMMERCE
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PB-281 517

San Carlos Reservoir Gila, Graham, and Pinal Counties, Arizona

National Eutrophication Survey, Las Vegas, Nev

Prepared for

Environmental Monitoring and Support Lab, Las Vegas, Nev

Aug 77

PB 281 517

U.S. ENVIRONMENTAL PROTECTION AGENCY
NATIONAL EUTROPHICATION SURVEY

WORKING PAPER SERIES

CORVALLIS ENVIRONMENTAL RESEARCH LABORATORY - CORVALLIS, OREGON

and

ENVIRONMENTAL MONITORING & SUPPORT LABORATORY - LAS VEGAS, NEVADA

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U. S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

G.P.O. 699-440

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Report

on

San Carlos Reservoir

Gila, Graham, and Pinal Counties

Arizona

EPA Region IX

Working Paper No. 736

With the cooperation of the

Arizona State Department of Health

and the

Arizona National Guard

August, 1977

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO. PB281517
4. TITLE AND SUBTITLE Report on San Carlos Reservoir, Gila, Graham, and Pinal Counties, Arizona		5. REPORT DATE Prepared August 1977 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Anonymous (National Eutrophication Survey Staff)		8. PERFORMING ORGANIZATION REPORT NO. Working Paper # 736
9. PERFORMING ORGANIZATION NAME AND ADDRESS Environmental Monitoring and Support Laboratory P.O. Box 15027 Las Vegas, Nevada 89114		10. PROGRAM ELEMENT NO. 1BA029 11. CONTRACT/GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Office of Research and Development U.S. Environmental Protection Agency 401 M. Street, S. W. Washington, DC 20460		13. TYPE OF REPORT AND PERIOD COVERED Final - 1975 14. SPONSORING AGENCY CODE.

15. SUPPLEMENTARY NOTES

Prepared in cooperation with the U.S. Environmental Protection Agency, Pacific Northwest Environmental Research Laboratory, Corvallis, Oregon 97330

16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
eutrophication lakes nutrients phosphorus nitrogen loading	National Eutrophication Survey Lake Survey	05B 05C

18. DISTRIBUTION STATEMENT Release Unlimited	19. SECURITY CLASS (This Report) Unclassified	21. NO. OF PAGES 46
	20. SECURITY CLASS (This page)	22. PRICE PC A03/MF A01

Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE

REPORT ON SAN CARLOS RESERVOIR

GILA, GRAHAM, AND PINAL COUNTIES, ARIZONA

EPA REGION IX

by

National Eutrophication Survey

Water and Land Quality Branch
Monitoring Operations Division
Environmental Monitoring & Support Laboratory
Las Vegas, Nevada

and

Special Studies Branch
Corvallis Environmental Research Laboratory
Corvallis, Oregon

Working Paper No. 736

OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY

August 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point source discharge reduction and nonpoint source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's freshwater lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by the U.S. Environmental Protection Agency and to augment plans implementation by the states.

ACKNOWLEDGMENTS

The staff of the National Eutrophication Survey (Office of Research and Development, U.S. Environmental Protection Agency) expresses sincere appreciation to the Arizona State Department of Health for professional involvement, to the Arizona National Guard for conducting the tributary sampling phase of the Survey, and to those Arizona wastewater treatment plant operators who provided effluent samples and flow data.

The staffs of the Bureau of Water Quality Control, Environmental Health Services, Arizona State Department of Health, and the Arizona Game and Fish Department, provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports and provided critiques most useful in the preparation of this Working Paper Series.

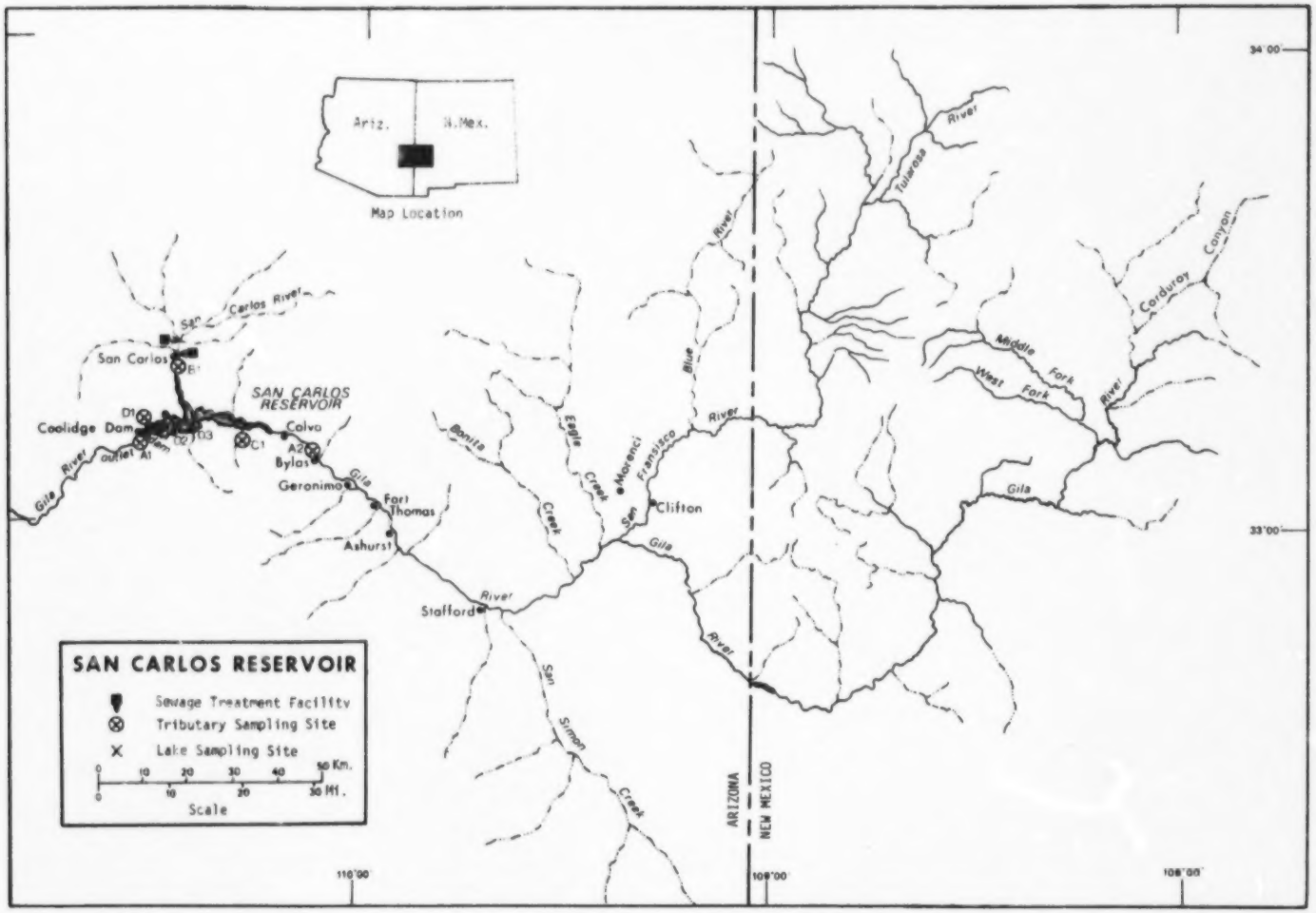
Major General John G. Smith, the Adjutant General of Arizona, and Project Officer Colonel Richard A. Colson, who directed the volunteer efforts of the Arizona National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

NATIONAL EUTROPHICATION SURVEY

STUDY LAKES

STATE OF ARIZONA

LAKE NAME	COUNTY
Big Lake	Apache
Fools Hollow Lake	Navajo
Lake Havasu	Mohave (San Bernadino in CA)
Luna Lake	Apache
Lyman Lake	Apache
Lake Mohave	Mohave (Clark in NV)
Lake Pleasant	Yavapai, Maricopa
Lake Powell	Coconino (Kane, Garfield, San Juan in UT)
Rainbow Lake	Navajo
Theodore Roosevelt Lake	Gila
San Carlos Reservoir	Graham, Gila, Pinal



Ariz.
N.Mex.
Map Location
SAN CARLOS RESERVOIR
Sewage Treatment Facility
Tributary Sampling Site
Lake Sampling Site
0 10 20 30 40 50 Km.
0 10 20 30 Mi.
Scale
San Carlos
San Carlos River
B1
D1
Coolidge Dam
D2
D3
A1
outlet
dam
C1
Calva
A2
Bylas
Geronimo
Fort Thomas
Ashurst
Stafford
Gila River
Bonita Creek
Eagle Creek
Morenci
San Francisco River
Clifton
Blue River
Tularosa River
Middle Fork
West Fork
Corduroy Canyon
San Simon Creek
ARIZONA
NEW MEXICO
34°00'
33°00'
110°00'
109°00'
108°00'

REPORT ON SAN CARLOS RESERVOIR, ARIZONA

STORET NO. 0411

I. CONCLUSIONS

A. Trophic Condition:*

Survey data indicate that San Carlos Reservoir is eutrophic, i.e., nutrient rich and highly productive. Whether such nutrient enrichment is to be considered beneficial or deleterious is determined by its actual or potential impact upon designated beneficial water uses of each lake.

Chlorophyll a values in the lake ranged from 7.4 µg/l to 33.2 µg/l, with a mean of 14.8 µg/l. Secchi disc visibility was low and potentials for primary productivity as measured by algal assay control yields were moderate. Of the 11 Arizona lakes sampled in 1975, 3 had higher median total phosphorus levels (0.056 mg/l), 5 had higher median inorganic nitrogen values (0.060 mg/l) and 5 had higher median orthophosphorus values (0.009) than San Carlos Reservoir.

Survey limnologists did not report any problem algal blooms or macrophyte growths during their visits to the lake.

*See Appendix E.

B. Rate-Limiting Nutrient:

Algal assay results indicate phosphorus limitation in San Carlos Reservoir during March and November visits to the lake. The lake data suggest nitrogen limitation throughout the lake on all three sampling occasions.

C. Nutrient Controllability:

1. Point sources -

During the sampling year, point sources were calculated to contribute 0.4% of the total phosphorus load to San Carlos Reservoir. The city of San Carlos contributed 0.3% and the Soda Canyon Recreation Area contributed 0.1%.

The present phosphorus loading of 9.35 g $P/m^2/yr$ is twenty times that proposed by Vollenweider (1975) as "eutrophic" for a lake of such volume and retention time. Vollenweider's model is not applicable to San Carlos Reservoir, however, as large fluctuations in water level result from the reservoir's use for downstream agricultural activities. Drawdown occurs regularly and in low water years the lake is essentially dry (W. H. Shafer, personal communication). Additional sampling is needed to better define the nutrient budget of the lake.

2. Nonpoint sources -

Nonpoint sources, including precipitation, contributed 99.6% of the total phosphorus input during the sampling year.

The Gila River contributed 92.4%, the San Carlos River contributed 4.1% and minor tributaries and immediate drainage contributed an estimated 2.9%.

II. LAKE AND DRAINAGE BASIN CHARACTERISTICS

Lake and drainage basin characteristics are itemized below. Lake morphometry data were provided by Ned Rathbun (1974). Average surface area and the 1973 average volume are indicated. Tributary flow data were provided by the Arizona District Office of the U.S. Geological Survey (USGS). Outlet drainage area includes the lake surface area. Mean hydraulic retention time was obtained by dividing the lake volume by mean flow of the outlet. Precipitation values were estimated by methods as outlined in NES Working Paper No. 175. A table of metric/English conversions is included as Appendix A.

A. Lake Morhphometry:

1. Surface area: 52.61 km^2.
2. Mean depth: 15.3 meters.
3. Maximum depth: 41.6 meters.
4. Volume: 806.679 x 10^6 m^3.
5. Mean hydraulic retention time: 1076 days (2.9 yr).

B. Tributary and Outlet:
(See Appendix B for flow data)

1. Tributaries

Name	Drainage area (km^2)	Mean Flow (m^3/sec)
A-2 Gila River	29,707.3	10.09
B-1 San Carlos River	2,659.3	1.62
Minor tributaries and immediate drainage -	954.9	0.51
Totals	33,321.5	12.22
2. Outlet - A-1 Gila River	33,374.7	8.68

C. Precipitation:

1. Year of sampling: 39.9 cm.
2. Mean annual: 45.8 cm.

III. LAKE WATER QUALITY SUMMARY

San Carlos Reservoir was sampled three times during the open-water season of 1975 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from four stations on the lake (Station 04 was only sampled once) and from one or more depths at each station (see map, page v). During each visit, depth-integrated samples were collected from each station for chlorophyll a analysis and phytoplankton identification and enumeration. During the first and last visits, 18.9-liter depth-integrated samples were composited for algal assays. Maximum depths sampled were 21.3 meters at Station 01, 7.3 meters at Station 02, 4.9 meters at Station 03, and the surface at Station 04. For a more detailed explanation of NES methods, see NES Working Paper No. 175.

The results obtained are presented in full in Appendix C and are summarized in III-A for waters at the surface and at the maximum depth for each site. Results of the phytoplankton counts and chlorophyll a determinations are included in III-B. Results of the limiting nutrient study are presented in III-C.

SAN CARLOS RESERVOIR
STORET CODE 0411

A. PHYSICAL AND CHEMICAL CHARACTERISTICS

PARAMETER	(3/ 4/75) S*** = 3 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(6/18/75) S*** = 4 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)	(11/18/75) S*** = 3 N*	RANGE	MEDIAN	MAX DEPTH RANGE (METERS)
TEMPERATURE (DEG CENT)												
0.-1.5 M DEPTH	6	11.3- 13.0	11.9	0.0- 1.5	6	18.3- 24.3	24.0	0.0- 1.5	5	12.2- 14.5	13.9	0.0- 1.5
MAX DEPTH**	3	8.9- 12.0	8.9	4.9- 21.3	3	15.3- 24.0	20.6	1.5- 18.6	3	12.2- 14.2	13.6	0.0- 15.8
DISSOLVED OXYGEN (MG/L)												
0.-1.5 M DEPTH	6	10.2- 13.2	10.8	0.0- 1.5	6	3.6- 8.6	7.0	0.0- 1.5	5	6.0- 9.6	7.2	0.0- 1.5
MAX DEPTH**	3	3.8- 9.6	9.2	4.9- 21.3	3	0.4- 7.4	7.0	1.5- 18.6	3	5.6- 9.6	7.4	0.0- 15.8
CONDUCTIVITY (UMHOS)												
0.-1.5 M DEPTH	6	1232.-1305.	1267.	0.0- 1.5	6	1217.-1547.	1488.	0.0- 1.5	5	975.-1039.	1020.	0.0- 1.5
MAX DEPTH**	3	1282.-1983.	1479.	4.9- 21.3	3	1051.-1547.	1274.	1.5- 18.6	3	1039.-1080.	1080.	0.0- 15.8
PH (STANDARD UNITS)												
0.-1.5 M DEPTH	6	7.9- 8.8	8.4	0.0- 1.5	7	7.9- 8.5	8.5	0.0- 1.5	5	8.3- 8.6	8.4	0.0- 1.5
MAX DEPTH**	3	7.8- 8.1	8.0	4.9- 21.3	4	7.8- 8.5	8.5	0.0- 18.6	3	8.3- 8.6	8.4	0.0- 15.8
TOTAL ALKALINITY (MG/L)												
0.-1.5 M DEPTH	6	166.- 172.	167.	0.0- 1.5	7	152.- 161.	159.	0.0- 1.5	5	150.- 163.	157.	0.0- 1.5
MAX DEPTH**	3	167.- 174.	171.	4.9- 21.3	4	152.- 166.	159.	0.0- 18.6	3	153.- 163.	154.	0.0- 15.8
TOTAL P (MG/L)												
0.-1.5 M DEPTH	6	0.021-0.030	0.025	0.0- 1.5	7	0.038-0.118	0.055	0.0- 1.5	5	0.064-0.083	0.072	0.0- 1.5
MAX DEPTH**	3	0.036-0.171	0.144	4.9- 21.3	4	0.056-0.118	0.084	0.0- 18.6	3	0.064-0.154	0.079	0.0- 15.8
DISSOLVED ORTHO P (MG/L)												
0.-1.5 M DEPTH	6	0.004-0.017	0.006	0.0- 1.5	7	0.007-0.019	0.008	0.0- 1.5	5	0.008-0.031	0.021	0.0- 1.5
MAX DEPTH**	3	0.007-0.011	0.007	4.9- 21.3	4	0.007-0.044	0.012	0.0- 18.6	3	0.014-0.023	0.021	0.0- 15.8
NO2+NO3 (MG/L)												
0.-1.5 M DEPTH	6	0.020-0.060	0.020	0.0- 1.5	7	0.020-0.020	0.020	0.0- 1.5	5	0.020-0.060	0.040	0.0- 1.5
MAX DEPTH**	3	0.020-0.100	0.080	4.9- 21.3	4	0.020-0.030	0.020	0.0- 18.6	3	0.020-0.050	0.040	0.0- 15.8
AMMONIA (MG/L)												
0.-1.5 M DEPTH	6	0.020-0.040	0.030	0.0- 1.5	7	0.020-0.050	0.030	0.0- 1.5	5	0.020-0.060	0.020	0.0- 1.5
MAX DEPTH**	3	0.030-0.120	0.030	4.9- 21.3	4	0.020-0.080	0.030	0.0- 18.6	3	0.020-0.060	0.020	0.0- 15.8
KJELDAHL N (MG/L)												
0.-1.5 M DEPTH	6	0.400-1.600	0.550	0.0- 1.5	7	0.400-0.800	0.500	0.0- 1.5	5	0.300-0.400	0.400	0.0- 1.5
MAX DEPTH**	3	0.600-0.600	0.600	4.9- 21.3	4	0.500-0.800	0.550	0.0- 18.6	3	0.400-0.400	0.400	0.0- 15.8
SECCHI DISC (METERS)												
	3	1.2- 1.3	1.2		2	0.3- 0.4	0.4		3	0.2- 0.3	0.3	

* N = NO. OF SAMPLES
** MAXIMUM DEPTH SAMPLED AT EACH SITE
*** S = NO. OF SITES SAMPLED ON THIS DATE

B. Biological Characteristics:

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units Per ml
03/04/75	1. Ankistrodesmus	2,045
	2. Cryptomonas	1,402
	3. Dactylococcopsis	584
	4. Kirchneriella	467
	5. Chroomonas?	380
	Other genera	1,256
	Total	6,134
06/18/75	1. Lyngbya	2,463
	2. Carteria	1,351
	3. Dactylococcopsis	530
	4. Centric diatom	424
	5. Ceratium	265
	Other genera	1,191
	Total	6,224
11/18/75	1. Chroomonas?	6,312
	2. Dactylococcopsis	207
	3. Euglena	89
	4. Mesostigma	59
	5. Chlamydomonas	59
	Other genera	327
	Total	7,053

2. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/04/75	01	7.7
	02	9.6
	03	14.9
	04	---
06/18/75	01	7.4
	02	16.2
	03	33.2
	04	21.1
11/18/75	01	8.6
	02	14.3
	03	14.5
	04	---

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

a. 03/04/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.010	0.168	0.4
0.05 P	0.060	0.168	7.0
0.05 P + 1.0 N	0.060	1.168	15.0
1.00 N	0.010	1.168	0.4

b. 11/18/75

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum Yield (mg/l-dry wt.)
Control	0.020	0.130	0.8
0.05 P	0.070	0.130	4.8
0.05 P + 1.0 N	0.070	1.130	3.8
1.00 N	0.020	1.130	0.8

2. Discussion -

The control yields of the assay alga, Selenastrum capricornutum*, indicate that the potential for primary production in San Carlos Reservoir was moderate at the times of sampling (03/04/75, 11/18/75). In both assays, the addition of phosphorus alone produced a significant increase in yield over that of the control, indicating phosphorus limitation. The addition of nitrogen alone did not produce any growth repsonse over that of the control.

The mean inorganic nitrogen to orthophosphorus ratios (N/P) in the lake data were 11/1 or less on all three sampling occasions, suggesting primary limitation by nitrogen in San Carlos Reservoir.

*For further information regarding the algal assay test procedure and selection of test organisms, see U.S. EPA (1971).

IV. NUTRIENT LOADINGS
(See Appendix D for data)

For the determination of nutrient loadings, the Arizona National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page v), except for the high runoff month of May when three samples were collected. Sampling was begun in December 1974, and was completed in November 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Arizona District Office of the USGS for the tributary sites nearest the lake.

In this report, nutrient loads for sampled tributaries were determined by using a modification of a USGS computer program for calculating stream loadings. Nutrient loads indicated for tributaries are those measured minus known point source loads, if any.

Nutrient loadings for unsampled "minor tributaries and immediate drainage" ("ZZ" of USGS) were estimated by using the mean annual nutrient loads, in kg/km^2/year in the Gila River at Station A-2, and multiplying the means by the ZZ area in km^2.

The operator of the San Carlos wastewater treatment plant provided monthly effluent samples and corresponding flow data. Nutrient loads for the Soda Canyon Recreation Area wastewater treatment plant were estimated at 1.134 kg P and 3.401 kg N/capita/year.

A. Waste Sources:

1. Known municipal -

Name	Pop.* Served	Treatment*	Mean Flow ($m^3/d \times 10^3$)	Receiving Water
Soda Canyon Recreation Area	200	Activated Sludge	0.076**	San Carlos River
San Carlos	2,700	Stabilization Pond	0.616	San Carlos River

2. Known industrial - None

*Provided by the treatment plant operator.
**Estimated at 0.3785 m^3/capita/day.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 Gila River	454,795	92.4
B-1 San Carlos River	20,375	4.1
b. Minor tributaries and immediate drainage (nonpoint load) -	14,325	2.9
c. Known municipal STP's -		
Soda Canyon Recreation Area	225	0.1
San Carlos	1,340	0.3
d. Septic tanks - None known		
e. Known industrial - None		
f. Direct precipitation* -	920	0.2
Totals	491,980	100.0

2. Outputs - A-1 Gila River 10,165

3. Net annual P accumulation - 481,815

*Estimated (See NES Working Paper No. 175).

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (nonpoint load) -		
A-2 Gila River	927,960	86.2
B-1 San Carlos River	58,780	5.5
b. Minor tributaries and immediate drainage (nonpoint load) -	29,600	2.7
c. Known municipal STP's -		
Soda Canyon Recreation Area	680	<0.1
San Carlos	3,000	0.3
d. Septic tanks - None known		
e. Known industrial - None		
f. Direct precipitation* -	56,800	5.3
Totals	1,076,820	100.0

2. Outputs - A-1 Gila River 239,960

3. Net annual N accumulation - 836,860

*Estimated (See NES Working Paper No. 175).

D. Mean Annual Nonpoint Nutrient Export by Subdrainage Area:

Tributary	kg P/km^2/yr	kg N/km^2/yr
A-2 Gila River	15	31
B-1 San Carlos River	8	22

E. Yearly Loadings:

In the following table, the existing phosphorus annual loading is compared to the relationship proposed by Vollenweider (1975). Essentially, his "eutrophic" loading is that at which the receiving waters would become eutrophic or remain eutrophic; his "oligotrophic" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A "mesotrophic" loading would be considered one between "eutrophic" and "oligotrophic".

Note that Vollenweider's model may not apply to lakes with short hydraulic retention times or in which light penetration is severely restricted by high concentrations of suspended solids in the surface waters.

	Total Yearly Phosphorus Loading (g/m^2/yr)
Estimated loading for San Carlos Reservoir	9.35
Vollenweider's "eutrophic" loading	0.45
Vollenweider's "oligotrophic" loading	0.22

V. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

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APPENDIX B

TRIBUTARY FLOW DATA

TRIBUTARY FLOW INFORMATION FOR ARIZONA 11/26/76

LAKE CODE 0411 SAN CARLOS

TOTAL DRAINAGE AREA OF LAKE(SQ KM) 33374.7

NORMALIZED FLOWS(CMS)

TRIBUTARY	SUB-DRAINAGE AREA(SQ KM)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
0411A1	33374.7	1.42	5.66	11.33	11.33	12.46	14.72	16.99	12.74	9.06	2.55	1.42	4.25	8.68
0411A2	29707.3	14.16	16.99	19.82	12.74	7.93	1.42	1.42	8.50	5.10	15.86	4.53	12.74	10.09
0411B1	2659.9	1.699	2.832	2.407	0.566	0.227	0.057	0.425	1.133	0.566	2.265	0.425	6.796	1.620
0411ZZ	1007.5	0.566	0.850	0.850	0.227	0.085	0.028	0.170	0.425	0.227	0.850	0.142	1.699	0.511

SUMMARY

TOTAL DRAINAGE AREA OF LAKE = 33374.7
SUM OF SUB-DRAINAGE AREAS = 33374.7

TOTAL FLOW IN = 146.71
TOTAL FLOW OUT = 103.92

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
0411A1	12	74	7.985	8	6.768	8	7.079		
	1	75	7.787	11	6.513				
	2	75	11.893	15	11.327				
	3	75	19.340	15	20.388				
	4	75	13.819	12	10.024				
	5	75	19.878	1	19.425	0	0.0		
	6	75	20.898	14	23.078				
	7	75	16.339	10	19.737				
	8	75	19.086	7	19.624				
	9	75	14.895	16	14.866				
	10	75	7.108	18	7.985				
	11	75	0.117	10	0.091				
0411A2	12	74	1.631	8	1.331				
	1	75	1.130	11	0.991				
	2	75	5.380	15	3.256				
	3	75	13.366	15	22.710				
	4	75	12.743	12	15.291				
	5	75	3.228	1	8.608	0	0.0		
	6	75	0.547	14	0.538				
	7	75	1.073	10	0.122				
	8	75	0.208	7	0.122				
	9	75	47.601	16	70.792				
	10	75	4.899	18	2.917				
	11	75	3.964	10	3.908				

TRIBUTARY FLOW INFORMATION FOR ARIZONA 11/26/76

LAKE CODE 0411 SAN CARLOS

MEAN MONTHLY FLOWS AND DAILY FLOWS(CMS)

TRIBUTARY	MONTH	YEAR	MEAN FLOW	DAY	FLOW	DAY	FLOW	DAY	FLOW
041181	12	74	0.396	8	0.396				
	1	75	0.436	11	0.396				
	2	75	1.798	15	5.833	15	0.708		
	3	75	1.450	15	2.747				
	4	75	3.058	12	9.118	12	10.760		
	5	75	0.232	1	0.340				
	5	75	0.232	7	0.311				
	5	75	0.232	30	0.156				
	6	75	0.098	14	0.093				
	7	75	0.428	10	0.130				
	8	75	0.136	7	0.122				
	9	75	0.245	16	0.181				
	10	75	0.161	18	0.156				
	11	75	0.229	10	0.198				
041122	12	74	0.170						
	1	75	0.170						
	2	75	0.566						
	3	75	0.510						
	4	75	1.133						
	5	75	0.113						
	6	75	0.057						
	7	75	0.170						
	8	75	0.057						
	9	75	0.113						
	10	75	0.057						
	11	75	0.085						

APPENDIX C

PHYSICAL AND CHEMICAL DATA

STORET RETRIEVAL DATE 76/11/26
NATL EUTROPHICATION SURVEY
EPA-LAS VEGAS

041101
33 10 33.0 110 31 38.0 3
SAN CARLOS RESERVOIR
04007 ARIZONA

110491

11EPALES 2111202
0074 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/04	10 35	0000	11.4	10.2	51	1305	8.40	172	0.040	1.600	0.060	0.007
	10 35	0005	11.3	10.4		1261	8.40	170	0.020	0.400	0.040	0.004
	10 35	0020	9.1	7.6		1287	8.10	167	0.030	0.600	0.100	0.005
	10 35	0040	8.7	7.4		1248	8.00	168	0.020	0.400	0.130	0.005
	10 35	0055	8.6	5.2		1287	7.90	167	0.030	0.400	0.190	0.009
	10 35	0070	8.9	3.8		1479	7.80	174	0.120	0.600	0.100	0.011
75/06/18	11 25	0000	18.4	8.6		1220	7.90	159	0.030	0.500	0.020K	0.007
	11 25	0005	18.3	3.6		1217	7.90	160	0.030	0.400	0.020K	0.007
	11 25	0015	18.3	3.8		1216	7.85	159	0.020	0.400	0.020K	0.008
	11 25	0035	17.7	2.2		1195	7.80	159	0.030	0.400	0.020K	0.016
	11 25	0061	15.3	0.4		1051	7.75	166	0.080	0.500	0.030	0.044
75/11/18	09 45	0000	14.4	6.4	11	991	8.25	150	0.060	0.400	0.060	0.018
	09 45	0005	14.5	6.0		1020	8.30	151	0.060	0.400	0.060	0.031
	09 45	0015	14.5	6.0		1041	8.30	150	0.060	0.400	0.060	0.028
	09 45	0030	14.4	5.8		1071	8.30	155	0.080	0.400	0.040	0.025
	09 45	0052	14.2	5.6		1080	8.30	153	0.060	0.400	0.050	0.021

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/04	10 35	0000	0.025	7.7	
	10 35	0005	0.024		
	10 35	0020	0.273		
	10 35	0040	0.021		
	10 35	0055	0.022		
	10 35	0070	0.171		
75/06/18	11 25	0000	0.039	7.4	
	11 25	0005	0.038		
	11 25	0015	0.039		
	11 25	0035	0.043		
	11 25	0061	0.110		
75/11/18	09 45	0000	0.080	8.6	
	09 45	0005	0.083		
	09 45	0015	0.077		
	09 45	0030	0.084		
	09 45	0052	0.154		

K VALUE KNOWN TO BE LESS THAN INDICATED

24

STORET RETRIEVAL DATE 76/11/26
NATL EUTROPHICATION SURVEY
EPA-LAS VEGAS

041102
33 11 25.0 110 25 47.0 3
SAN CARLOS RESERVOIR
04007 ARIZONA
110491

11EPALES 2111202
0028 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/04	11 35	0000	12.2	10.2	48	1272	8.20	166	0.030	0.800	0.020K	0.017
	11 35	0005	11.6	11.2		1277	8.65	166	0.020	0.400	0.020K	0.009
	11 35	0015	9.9	6.8				167	0.020	0.400	0.080	0.005
	11 35	0024	8.9	9.2		1282	8.00	167	0.030	0.600	0.080	0.007
75/06/19	13 25	0000	24.3	7.4	17	1490	8.50	160	0.030	0.600	0.020K	0.008
	13 25	0005	24.2	6.2		1485	8.45	158	0.040	0.400	0.020K	0.013
	13 25	0015	21.9	5.2		1406	8.10	158	0.040	0.400	0.020K	0.014
	13 25	0024	20.6	7.4		1274	8.50	159	0.030	0.500	0.020K	0.011
75/11/18	09 25	0000	13.9	8.4	12	975	8.50	163	0.020	0.400	0.020	0.008
	09 25	0005	13.8	7.2		1026	8.40	157	0.020	0.300	0.040	0.021
	09 25	0014	13.6	7.4		1080	8.40	154	0.020	0.400	0.040	0.014

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/04	11 35	0000	0.026	9.6	
	11 35	0005	0.028		
	11 35	0015	0.018		
	11 35	0024	0.036		
75/06/19	13 25	0000	0.053	16.2	
	13 25	0005	0.055		
	13 25	0015	0.040		
	13 25	0024	0.058		
75/11/18	09 25	0000	0.072	14.3	
	09 25	0005	0.066		
	09 25	0014	0.079		

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 76/11/26
NATL EUTROPHICATION SURVEY
EPA-LAS VEGAS

041103
33 11 40.0 110 24 25.0 3
SAN CARLOS RESERVOIR
04007 ARIZONA

110491

11EPALES 2111202
0020 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/03/04	12 15	0000	13.0	12.8	48	1258	7.95	167	0.030	0.500	0.020K	0.005
	12 15	0005	12.5	13.2		1232	8.75	166	0.030	0.600	0.020K	0.006
	12 15	0010	12.0	10.8		1668	8.40	171	0.030	0.600	0.020K	0.007
	12 15	0016	12.0	9.6		1983	8.15	171	0.030	0.600	0.020K	0.007
75/06/19	13 05	0000	24.1	7.0	11	1546	8.55	161	0.050	0.500	0.020K	0.019
	13 05	0005	24.0	7.0		1547	8.55	159	0.030	0.600	0.020K	0.014
75/11/18	09 10	0000	12.2	9.6	6	1039	8.60	163	0.020	0.400	0.020K	0.023

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/03/04	12 15	0000	0.021	14.9	
	12 15	0005	0.030		
	12 15	0010	0.142		
	12 15	0016	0.144		
75/06/19	13 05	0000	0.107	33.2	
	13 05	0005	0.056		
75/11/18	09 10	0000	0.064	14.5	

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 76/11/26
NATL EUTROPHICATION SURVEY
EPA-LAS VEGAS

041104
33 11 54.0 110 24 26.0 3
SAN CARLOS RESERVOIR
04009 ARIZONA

11EPALES 760109 2111202
0999 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00010 WATER TEMP CENT	00300 DO MG/L	00077 TRANSP SECCHI INCHES	00094 CNDUCTVY FIELD MICROMHO	00400 PH SU	00410 T ALK CACO3 MG/L	00610 NH3-N TOTAL MG/L	00625 TOT KJEL N MG/L	00630 NO2&NO3 N-TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P
75/06/18	11 00	0000					8.50	152	0.020	0.800	0.020	0.007

DATE FROM TO	TIME OF DAY	DEPTH FEET	00665 PHOS-TOT MG/L P	32217 CHLRPHYL A UG/L	00031 INCDT LT REMNING PERCENT
75/06/18	11 00	0000	0.118	21.1	

APPENDIX D

TRIBUTARY AND WASTEWATER TREATMENT PLANT DATA

STORET RETRIEVAL DATE 76/11/30
NATL EUTROPHICATION SURVEY
EPA- LAS VEGAS

0411A1
33 10 10.0 110 31 50.0 4
GILA RIVER
04 7.5 COOLIDGE DAM
O/SAN CARLOS RESERVOIR 110491
UNMPRVD RD XING .5 M DWNSTRM COOLIDGE DM
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/12/08	12 30		0.016	0.600	0.060	0.010	0.040
75/01/11	13 35		0.024	1.300	0.168	0.010	0.020
75/02/15	10 50		0.070		0.104	0.016	0.030
75/03/15			0.112	0.600	0.028	0.008	0.070
75/04/12	11 00		0.035	1.000	0.063	0.010	0.020
75/05/01	16 00		0.115	0.600	0.025	0.005K	0.050
75/05/07	12 15		0.115	2.100	0.060	0.015	0.030
75/05/30	11 10		0.045	0.300	0.055	0.035	0.040
75/06/14	16 30		0.005	0.400	0.135	0.055	0.070
75/07/10	07 20		0.005	0.900	0.250	0.090	0.120
75/08/07	11 30		0.005	1.050	0.470	0.090	0.130
75/09/16	09 30		0.420	0.700	0.095	0.100	0.170
75/10/18	10 30		0.090	0.600	0.070	0.035	0.100
75/11/10	11 48		0.155	3.500	0.120	0.130	0.750

K VALUE KNOWN TO BE LESS
THAN INDICATED

STORET RETRIEVAL DATE 76/11/30
NATL EUTROPHICATION SURVEY
EPA- LAS VEGAS

0411A2
33 10 00.0 110 08 05.0 4
GILA RIVER
04 15 BYLAS
T/SAN CARLOS RESERVOIR 110491
HWY 70 BRDG 2 MI NNW OF BYLAS
11EPALES 2111204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/12/08	11 50		1.600	0.300	0.020	0.065	0.080
75/01/11	11 15		1.600	1.600	0.040	0.005K	0.010
75/02/15	11 15		1.450	0.600	0.016	0.120	0.440
75/03/15	11 00		0.507	3.700	0.152	0.104	
75/04/12	10 25		0.760	2.800	0.120	0.095	0.960
75/05/01	15 45		0.810	0.900	0.020	0.070	0.500
75/05/07	12 00		1.350	1.000	0.110	0.090	0.290
75/05/30	10 55		1.500	0.250	0.030	0.010	0.01[illegible]
75/06/14	14 30		0.460	0.900	0.070	0.010	0.0[illegible]
75/07/10	07 10		0.390	0.750	0.050	0.015	0.020
75/08/07	11 50		0.005	0.650	0.030	0.015	0.070
75/09/16	09 45		0.290		0.025	0.135	
75/10/18	11 00		0.830	0.300	0.015	0.070	0.120
75/11/10	11 25		0.710	0.800	0.015	0.065	0.140

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 76/11/30
NATL EUTROPHICATION SURVEY
EPA- LAS VEGAS

041181
33 19 20.0 110 26 48.0 4
SAN CARLOS RIVER
04 7.5 SAN CARLOS
T/SAN CARLOS RESERVOIR 110491
SEC RD BRDG 2.4 MI S OF SAN CARLOS
11EPALES 211204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P
74/12/08	11 05		0.216	0.500	0.015	0.135	0.170
75/01/11	10 40		0.200	1.400	0.400	0.125	0.150
75/02/15	11 35		0.115	0.300	0.040	0.120	0.150
75/03/15	10 45		0.064	0.900	0.028	0.136	0.660
75/04/12	10 10		0.055	2.600	0.040	0.160	1.100
75/05/01	15 30		0.025	1.450	0.035	0.100	0.180
75/05/07	12 30		0.050	1.150	0.045	0.110	0.120
75/05/30	10 31		0.135	0.175	0.015	0.100	0.100
75/06/14	14 10		0.160	0.350	0.020	0.080	0.080
75/07/10	18 50		0.030	0.450	0.020	0.140	0.152
75/08/07	12 15		0.005	2.850	0.030	0.185	0.230
75/09/16	11 30		0.030	1.200	0.015	0.190	0.380
75/10/18	10 45		0.025	0.600	0.015	0.240	0.270
75/11/10	11 03		0.010	0.800	0.005K	0.190	0.220

K VALUE KNOWN TO BE LESS THAN INDICATED

STORET RETRIEVAL DATE 76/11/30
NATL EUTROPHICATION SURVEY
EPA- LAS VEGAS

0411DA AS0411DA P000200
33 20 45.0 110 27 00.0 4
SODA CANYON REC AREA
04 7.5 SAN CARLOS
T/SAN CARLOS LAKE 110491
SODA CANYON
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/05/12	08	00	27.000	5.600	0.069	9.800	10.500		
75/12/08	00	00	19.800	2.500	0.025K	4.400	5.900		

K VALUE KNOWN TO BE LESS
THAN INDICATED

32

STORET RETRIEVAL DATE 76/11/30
NATL EUTROPHICATION SURVEY
EPA- LAS VEGAS

0411XA PD0411XA P002700
33 21 00.0 110 27 00.0 4
SAN CARLOS
04 7.5 SAN CARLOS
T/SAN CARLOS LAKE 110491
SEVEN MILE WASH
11EPALES 2141204
0000 FEET DEPTH CLASS 00

DATE FROM TO	TIME OF DAY	DEPTH FEET	00630 NO2&NO3 N-TOTAL MG/L	00625 TOT KJEL N MG/L	00610 NH3-N TOTAL MG/L	00671 PHOS-DIS ORTHO MG/L P	00665 PHOS-TOT MG/L P	50051 FLOW RATE INST MGD	50053 CONDUIT FLOW-MGD MONTHLY
75/05/02	13 00		0.200	15.500	0.400	4.600	7.000		
75/06/05	14 00		0.050	9.600		3.700	4.600		
75/07/08	12 40		0.100	8.750	0.025	3.600	4.100		
75/08/04	11 00		0.250	9.025	0.050K	3.400	4.000		
75/09/03	13 00		0.400	8.700	0.120	4.050	4.800	0.790	0.179
75/10/02	14 20		0.800	7.100	0.025K	4.050	4.800	0.165	0.160
75/11/05	13 00		1.800	10.000	0.091	4.800	6.000	0.170	0.165
75/12/04	13 00		0.200	17.000	1.200	5.200	7.800	0.160	0.155
76/01/07	10 00		0.375	23.000	1.150	0.180	7.400	0.155	0.165
76/02/09	15 40		0.300	15.000	0.130	5.300	7.100	0.170	0.160
76/03/01	13 00		0.195	18.000	8.500	4.200	6.800	0.165	0.160
76/04/02	08 15		0.175	20.000	3.130	6.750	7.500	0.170	0.160
76/05/13	13 20			11.500			6.000	0.170	0.160

K VALUE KNOWN TO BE LESS
THAN INDICATED

33A

APPENDIX E

PARAMETRIC RANKINGS OF LAKES SAMPLED BY NES IN 1975

STATE OF ARIZONA

Mean or median values for six of the key parameters evaluated in establishing the trophic conditions of Arizona lakes sampled are presented to allow direct comparison of the ranking, by parameter, of each lake relative to the others. Median total phosphorus, median inorganic nitrogen and median dissolved orthophosphorus levels are expressed in mg/l. Chlorophyll a values are expressed in µg/l. To maintain consistent rank order with the preceding parameters, the mean Secchi disc depth, in inches, is subtracted from 500. Similarly, minimum dissolved oxygen values are subtracted from 15 to create table entries.

LAKE DATA TO BE USED IN RANKINGS VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P		MEDIAN INORG N		5000-MEAN SEC		MEAN CHLORA		15-MIN DO		MEDIAN DISS ORTHO P	
0401	BIG LAKE	0.032	5)	0.090	4)	386.000	9)	2.900	8)	9.000	8)	0.007	8)
0402	FOWLS HOLLOW	0.059	2)	0.090	4)	466.600	2)	10.683	2)	14.800	1)	0.014	2)
0403	LAKE HAWASU	0.015	10)	0.270	3)	420.231	7)	3.948	6)	10.800	7)	0.005	10)
0404	LUNA LAKE	0.182	0)	0.050	8)	396.250	8)	3.400	7)	12.000	4)	0.131	0)
0405	LYMAN LAKE	0.099	1)	0.060	7)	484.667	0)	2.633	9)	9.000	8)	0.056	1)
0406	LAKE MOHAVE	0.017	9)	0.240	2)	369.867	10)	4.404	4)	8.600	10)	0.010	3)
0407	LAKE PLEASANT	0.027	6)	0.040	10)	449.154	4)	9.808	3)	14.900	0)	0.004	11)
0408	LAKE POWELL	0.009	11)	0.400	1)	239.000	11)	1.833	10)	12.200	4)	0.010	3)
0409	RAINBOW LAKE	0.046	4)	0.045	9)	440.750	5)	16.367	0)	12.000	6)	0.009	5)
0410	ROOSEVELT LAKE	0.020	7)	0.040	10)	429.917	6)	4.073	5)	14.000	3)	0.008	7)
0411	SAN CARLOS RESERVOIR	0.056	3)	0.060	6)	474.500	1)	14.750	1)	14.600	2)	0.009	6)
3201	LAKE MEAD	0.020	7)	0.505	0)	453.600	3)	1.850	11)	8.000	11)	0.007	9)

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	MEDIAN TOTAL P	MEDIAN INORG N	500-MEAN SEC	MEAN CHLORA	15-MIN DO	MEDIAN DISS ORTHO P
0401	BIG LAKE	45 (5)	41 (4)	82 (9)	73 (8)	77 (8)	73 (8)
0402	FOOLS HOLLOW	18 (2)	41 (4)	18 (2)	18 (2)	9 (1)	18 (2)
0403	LAKE HAVASU	91 (10)	27 (3)	64 (7)	55 (6)	64 (7)	91 (10)
0404	LUNA LAKE	0 (0)	73 (8)	73 (8)	64 (7)	41 (4)	0 (0)
0405	LYMAN LAKE	9 (1)	64 (7)	0 (0)	82 (9)	77 (8)	9 (1)
0406	LAKE MOHAVE	82 (9)	18 (2)	91 (10)	36 (4)	91 (10)	32 (3)
0407	LAKE PLEASANT	55 (6)	95 (10)	36 (4)	27 (3)	0 (0)	100 (11)
0408	LAKE POWELL	100 (11)	9 (1)	100 (11)	91 (10)	41 (4)	32 (3)
0409	RAINBOW LAKE	36 (4)	82 (9)	45 (5)	0 (0)	55 (6)	45 (5)
0410	ROOSEVELT LAKE	68 (7)	95 (10)	55 (6)	45 (5)	27 (3)	64 (7)
0411	SAN CARLOS RESERVOIR	27 (3)	55 (6)	9 (1)	9 (1)	18 (2)	55 (6)
3201	LAKE MEAD	68 (7)	0 (0)	27 (3)	100 (11)	100 (11)	82 (9)